

Chemistry

AP

Mid-year

Exam

NAME _____

Test Number:

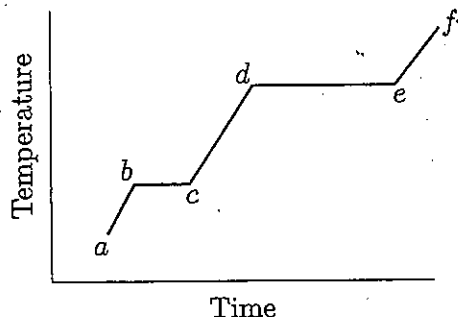
Part 1 - Multiple choice

1. Radiation in this region has the highest energy
 - a. Infrared
 - b. Microwaves
 - c. Ultraviolet
 - d. Visible
 - e. X-rays
2. The overall electron configuration of the sulfide ion is most similar to (isoelectronic with) the electron configuration of the
 - a. Oxide ion
 - b. Chloride atom
 - c. Oxygen atom
 - d. Sodium ion
 - e. Potassium ion
3. Of the elements listed, which is the heaviest element whose atoms have more s electrons than p electrons in total
 - a. ${}_5\text{B}$
 - b. ${}_7\text{N}$
 - c. ${}_9\text{F}$
 - d. ${}_{12}\text{Mg}$
 - e. ${}_{13}\text{Al}$
4. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of $6 \times 10^{15} \text{ sec}^{-1}$?
 - a. 10
 - b. 25
 - c. 50
 - d. 75
 - e. 100
5. Which description of electron configuration applies to atoms of potassium, chromium and copper?
 - a. Only one half-filled orbital
 - b. Only one filled sublevel
 - c. Only three half-filled orbitals
 - d. Only nine filled orbitals
 - e. Only five filled sublevels
6. What is the number of electrons in an atom of ${}_{23}\text{V}$ that have an l quantum number of 2?
 - a. 2
 - b. 3
 - c. 6
 - d. 10
 - e. 12
7. Consider the set of quantum numbers: 3, 2, -1, -1/2. Which set of quantum numbers represents an electron with the same energy but different orientation in space as the electron represented?
 - a. 3, 2, -1, +1/2
 - b. 3, 1, -1, -1/2
 - c. 3, 2, 0, +1/2
 - d. 2, 1, 0, +1/2
 - e. 2, 2, -1, -1/2

8. What is the number of filled orbitals in the ground state atom of manganese, ${}_{25}\text{Mn}$?
- 7
 - 10
 - 12
 - 13
 - 15
9. Which color in the visible spectrum is associated with the lowest frequency?
- Blue
 - Green
 - Red
 - Violet
 - Yellow
10. According to quantum mechanics, what is the maximum number of electrons that can occupy the third energy level in a ground state atom?
- 2
 - 4
 - 8
 - 18
 - 32
11. Copper wire is considered which type of solid?
- Ionic solid
 - Metallic solid
 - Network solid with covalent bonds
 - Molecular solid with hydrogen bonds
 - Molecular solid with nonpolar molecules
12. Magnesium sulfate crystals are considered which type of solid?
- Ionic solid
 - Metallic solid
 - Network solid with covalent bonds
 - Molecular solid with hydrogen bonds
 - Molecular solid with nonpolar molecules
13. All of these molecular shapes can be explained by sp^3d hybridization of electrons in the central atom EXCEPT
- Linear
 - T-shaped
 - See-saw
 - Octahedral
 - Trigonal bipyramidal
14. All species below have Lewis structures that illustrate the octet rule EXCEPT
- NO_3^{-1}
 - NH_3
 - NH_4^{+1}
 - N_2
 - NO_2
15. Which of the following exhibits a bent molecular geometry?
- HF
 - NH_3
 - CH_4
 - NO_2^{-1}
 - NO_3^{-1}

16. Which substance has the greatest ionic character?
- Cl_2O
 - NCl_3
 - PbCl_2
 - MgCl_2
 - CH_2Cl_2
17. Each of the following species is described by one of the following geometries (linear, bent, T-shaped, trigonal planar, trigonal pyramidal) EXCEPT
- BeF_2
 - BF_3
 - CCl_4
 - BrI_3
 - H_2O
18. The PF_6^- ion is known to have octahedral geometry. Explanation of its bonding includes all of the following EXCEPT
- Resonance structures
 - Expanded octets
 - sp^3d^2 hybridization
 - electrons shared as single bonds
19. What is the hybridization in the ammonia molecule, NH_3 ?
- sp
 - sp^2
 - sp^3
 - sp^3d
 - sp^3d^2
20. Consider the molecule C_4H_6 . Which identifies the correct numbers of sigma and pi bonds in the molecule?
- 1 sigma, 2 pi
 - 6 sigma, 3 pi
 - 7 sigma, 2 pi
 - 7 sigma, 4 pi
 - 9 sigma, 2 pi
21. The best description of the phase of the system as it changes from the conditions of point c to d on the graph is?
- Mix of liquid and gas
 - Mix of liquid and solid
 - Liquid at a constant temperature
 - Liquid with increasing temperature
 - Liquid with decreasing temperature
22. The density of an unknown gas is found to be 3.00g/L. Under the same conditions, the density of oxygen is found to be 2.00g/L. The molar mass of the unknown gas is closest to
- 14 g
 - 24 g
 - 36 g
 - 48 g
 - 72 g

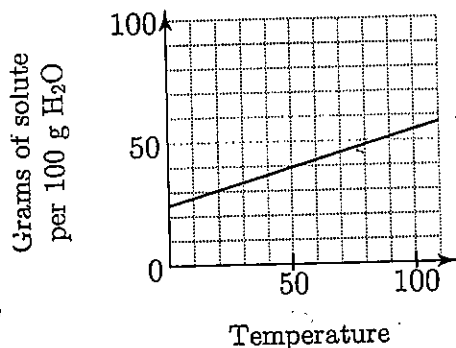
Figure 1



23. Which region of the graph represents the greatest change in potential energy of the system?
 - a. A-B
 - b. B-C
 - c. C-D
 - d. D-E
 - e. E-F
24. Which region of the graph represents the condition where the rate of increase in the number of molecules in the gas phase per unit time is the greatest?
 - a. A-B
 - b. B-C
 - c. C-D
 - d. D-E
 - e. E-F
25. Under the same conditions of pressure, sulfur dioxide liquefies at a much higher temperature than carbon dioxide. Which best accounts for this difference?
 - a. Each sulfur dioxide has a greater volume than carbon dioxide
 - b. Stronger forces of attraction exist between sulfur dioxide molecules than between carbon dioxide molecules
 - c. S-O bonds illustrate resonance, C-O bonds do not
 - d. Each sulfur dioxide molecule has a greater molecular mass than a carbon dioxide molecule
 - e. At the same conditions of temperature and pressure, a sulfur dioxide molecule has greater density than a carbon dioxide molecule
26. Which property of hydrogen sulfide is LEAST related to the polarity of its molecules
 - a. Molar mass
 - b. Solubility in water
 - c. Critical temperature
 - d. Normal boiling point
 - e. Elasticity of molecular collisions
27. Consider a sample of gas confined at constant temperature and volume in a closed system. If more of this same gas is added at constant temperature, what effect is observed on pressure and average molecular velocity?
 - a. Both pressure and average molecular velocity increase
 - b. Pressure decreases and average molecular velocity remains the same
 - c. Pressure remains the same and average molecular velocity increases
 - d. Pressure increases and average molecular velocity remains the same
 - e. Pressure remains the same and average molecular velocity decreases

28. When a sample of an ideal gas is heated from 20°C to 40°C, the average kinetic energy of the system changes. Which factor describes this change?
- $\frac{1}{2}$
 - 313 / 293
 - $(313 / 293)^{\frac{1}{2}}$
 - 293 / 313
 - 2
29. Solid CO₂ is observed to sublime at ordinary temperature and pressure. Which procedure would most likely prevent the loss of CO₂ due to sublimation?
- Submerge the solid into a container of dense oil at room temp.
 - Change the conditions to higher pressure and temperature
 - Change the conditions to higher pressure and lower temperature
 - Change the conditions to lower pressure and higher temperature
 - Change the conditions to lower pressure and temperature
30. Consider a sealed metal tank containing an ideal gas at room temperature. When this system is cooled to 273 kelvins, some other properties changes and some do not. Which gives a correct summary of changes in such properties?
- The density increases
 - The average molecular velocity increases
 - The pressure of the system decreases
- ii only
 - ii and iii only
 - i and iii only
 - iii only
 - i, ii, and iii
31. What is the final concentration of Cl⁻ ion when 250 mL of 0.20 M CaCl₂ solution is mixed with 250 mL of 0.40 M of KCl solution? (Assume additive volumes)
- 0.10 M
 - 0.20 M
 - 0.30 M
 - 0.40 M
 - 0.60 M
32. What is the mass percent of ammonium dichromate in water solution if 25 g of ammonium dichromate ((NH₄)₂Cr₂O₇, MM= 252.1 g) is dissolved in 100. g of water?
- 1.8%
 - 20%
 - 25%
 - 80%
 - 100%

Figure 2



33. At what temperature is the concentration of a saturated solution of KCl approximately 3.0 molality?
- 0°C
 - 35°C
 - 50°C
 - 80°C
 - 100°C
34. What is the mass percent of water in a saturated solution of KCl at 80°C?
- 20%
 - 33%
 - 50%
 - 67%
 - 80%
35. Which applies to a 1.0 M solution of potassium nitrate in water?
- Adding water raises the freezing point
 - Adding water increases the vapor pressure of the solution
 - Adding water decreases the density of the solution
- i only
 - ii and ii only
 - i and iii only
 - ii and iii only
 - i, ii and iii
36. Compared to water, a 0.20 M solution of NaCl will have all of the following properties EXCEPT
- Greater density
 - Lower vapor pressure
 - Lower boiling point
 - Lower freezing point
 - Greater conductivity
37. A saturated solution of KNO₃ in equilibrium with excess solute is prepared at 20°C. Which of the following describes the solution after the temperature of the system is increased to 40°C while still in contact with excess solute?
- The molality of the solution increases
 - The solution remains saturated
 - The density of the solution increases
- i only
 - iii only
 - i and iii only
 - ii and iii only
 - i, ii, and iii

38. A dilute solution of NaCl is prepared at 20°C. Which of the following describes the solution after the temperature of the solution is increased to 40°C?
- The vapor pressure increases
 - The number of ion pairs increases
 - The difference between freezing point and boiling point of the solution increases
- i only
 - iii only
 - i and ii only
 - i and iii only
 - i, ii, and iii
39. Which of these has the greatest percent by mass of oxygen?
- Barium oxide
 - Beryllium oxide
 - Calcium oxide
 - Magnesium oxide
 - Strontium oxide
40. Which pair of samples contains the same number of oxygen atoms in each compound?
- 0.10 mol Al_2O_3 and 0.50 mol BaO
 - 0.20 mol Cl_2O and 0.10 mol HClO
 - 0.20 mol SnO and 0.20 mol SnO_2
 - 0.10 mol Na_2O and 0.10 mol Na_2SO_4
 - 0.20 mol $\text{Ca}(\text{OH})_2$ and 0.10 mol $\text{H}_2\text{C}_2\text{O}_4$
41. What minimum volume of 0.200 M Na_2CO_3 is needed to precipitate all the Sr^{2+} from 25.0 mL of 0.100 M $\text{Sr}(\text{NO}_3)_2$?
- 6.25 mL
 - 12.5 mL
 - 25 mL
 - 50 mL
 - 100 mL
42. What mass of Al_2S_3 is produced when 1.50 moles of aluminum reacts with excess sulfur according to the equation? $2\text{Al} + 3\text{S} \rightarrow \text{Al}_2\text{S}_3$
- 40.5 g
 - 48.0 g
 - 61.5 g
 - 75.0 g
 - 113 g
43. When 0.60 mol ZnS was roasted in pure oxygen, 0.40 mol SO_2 was collected. Which best describes the contents of the solid phase remaining in the crucible?
- No excess ZnS; 0.60 mol ZnO
 - No excess ZnS; 0.30 mol ZnO
 - 0.20 mol excess ZnS; 0.30 mol ZnO
 - 0.20 mol excess ZnS; 0.40 mol ZnO
 - 0.30 mol excess ZnS; 0.40 mol ZnO

44. The mass of element X found in 1.0 mole each of four different compounds is 28 g, 42 g, 56 g, and 84 g, respectively. Which of the following is a possible atomic mass for element X?
- 14
 - 28
 - 35
 - 42

45-47 A mixture is prepared by adding 100. mL of 0.10 M Na_2CrO_4 to 100. mL of 0.10 M AgNO_3 . A precipitate forms in this mixture. The precipitate is separated by filtration.

45. What is the concentration of Na^+ in the reaction mixture after filtration?

- 0.050 M
- 0.10 M
- 0.15 M
- 0.20 M
- 0.40 M

46. What quantity of solid is produced?

- 0.0025 mol
- 0.0050 mol
- 0.010 mol
- 0.015 mol
- 0.020 mol

47. What describes the changes in the concentrations of the spectator ions, Na^+ and NO_3^- in the reaction mixture as the reaction occurs in the beaker.

- | Na^+ | NO_3^- |
|---------------------|------------------|
| a. increases | remains the same |
| b. remains the same | decreases |
| c. remains the same | remains the same |
| d. increases | decreases |
| e. decreases | decreases |

48. Which value is closest to the volume of O_2 measured at STP that could be produced when 0.20 mol KClO_3 is heated according to the equation? $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$

- 4.5 L
- 6.7 L
- 7.5 L
15. L
34. L

49. How many moles of KCl should be added to 0.500 liters of 0.20 M CrCl_3 solution to increase the chloride concentration to 1.00 M (assume no change in volume)

- 0.20
- 0.40
- 0.50
- 0.60
- 0.80

50. Epsom salt, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, (MM=252) can be dehydrated by heating in an open crucible. Which value is closest to the fraction of the mass in the crucible after heating.

- $\frac{1}{8}$
- $\frac{1}{4}$
- $\frac{1}{3}$
- $\frac{1}{2}$

Name _____

Part 2 – Free Response

1A. Use the principles of atomic structure to answer the following

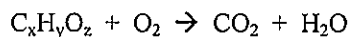
- Write the electron configuration and the lewis dot structure for a ground state atom of arsenic.
- The first ionization energy of arsenic is greater than the first ionization energy of germanium. Explain
- The second ionization energy of arsenic is greater than the first ionization energy of arsenic. Explain
- When an arsenic atom becomes an arsenide ion as in Na_3As , it gains three electrons. Write the set of four quantum numbers for these three added electrons

1B. Consider the carbonate ion, CO_3^{2-}

- Draw the VSEPR diagram and label the shape
- Discuss the hybridization of the central atom and how it determines the geometry
- Label the sigma and pi bonds for the molecule
- Describe the crystalline structure of calcium carbonate on the atomic level

Name _____

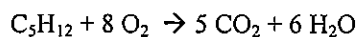
3. Answer the following question about a compound that only contains carbon, hydrogen and oxygen



- a. A 0.7549 g sample of the compound burns in excess O_2 to produce 1.9061 g of CO_2 and 0.3370 g of H_2O . Determine the empirical formula.
- b. A 0.5246 g sample of the compound was dissolved in 10.0012 g of lauric acid and it was determined that the freezing point of the lauric acid was lowered by 1.68°C . The value of K_f of lauric acid is 3.90. Assume the compound does not dissociate. Calculate the molality of the compound dissolved in lauric acid.
- c. Calculate the molar mass of the compound in (b) from the information provided.

Name _____

4. Consider the hydrocarbon C_5H_{12}

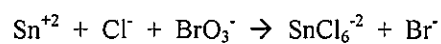


- What volume of dry carbon dioxide, measured at $25^\circ C$ and 785 mm Hg, will result from the complete combustion of 2.50 g of pentane.
- The complete combustion of 5.00 g of pentane releases 243 kJ of heat. What is the value of ΔH for one mole of pentane
- Under identical conditions, a sample of an unknown gas effuses into a vacuum a twice the rate that a sample of pentane gas effuses. What is the molar mass of the unknown sample

Name _____

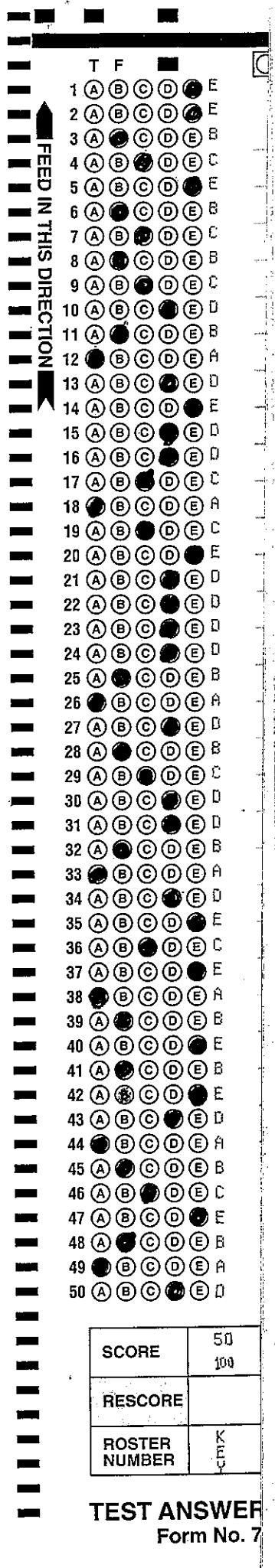
5. The salt NaBrO_3 oxidizes Sn^{+2} to SnCl_6^{-2} in the presence of hydrochloric acid

- a. Balance the redox equation in an acidic solution



- b. Determine the substance being oxidized and the substance being reduced.

- c. A sample of tin ore weighing 2.00g is dissolved in acid and all the tin present is converted to Sn^{+2} . For the reaction to be completed, 32.50 mL of a 0.0750 M of KBrO_3 solution is required. What was the percent tin, by mass, in the sample?

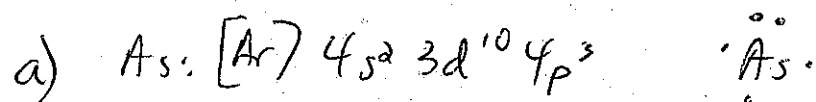


- T F
- 1 (A) (B) (C) (D) (E)
 - 2 (A) (B) (C) (D) (E)
 - 3 (A) (B) (C) (D) (E)
 - 4 (A) (B) (C) (D) (E)
 - 5 (A) (B) (C) (D) (E)
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 - 47 (A) (B) (C) (D) (E)
 - 48 (A) (B) (C) (D) (E)
 - 49 (A) (B) (C) (D) (E)
 - 50 (A) (B) (C) (D) (E)

SCORE	50 100
RESCORE	
ROSTER NUMBER	K 100

Part 2 - Free Response DO THREE OF THE FIVE be sure to cross out 2 problem pages.

1. Use the principles of atomic structure to answer the following
- Write the electron configuration and the lewis dot structure for a ground state atom of arsenic.
 - The first ionization energy of arsenic is greater than the first ionization energy of germanium. Explain
 - The second ionization energy of arsenic is greater than the first ionization energy of arsenic. Explain
 - When an arsenic atom becomes an arsenide ion as in Na_3As , it gains three electrons. Write the set of four quantum numbers for these three added electrons



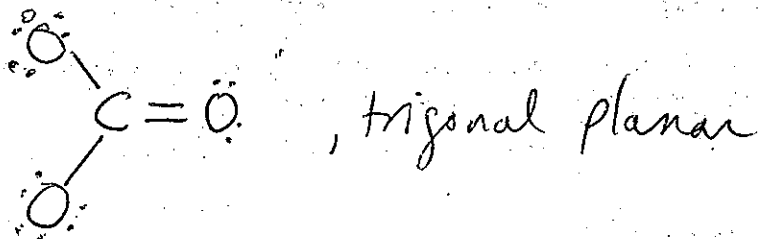
b) Ge has less $4p e^-$ so less IE

c) As lost $4e^-$ so holds the rest more strongly because it is $+1$

d) $4, 1, -1, -1/2$
0
 $+1$

2. Consider the carbonate ion, CO_3^{2-}

- Draw the VSEPR diagram and label the shape
- Discuss the hybridization of the central atom and how it determines the geometry
- Label the sigma and pi bonds for the molecule
- Describe the crystalline structure of calcium carbonate on the atomic level



b) sp^2 all 3 atoms of O. ~~repel~~ repel so
Bonds move as far apart as possible

c) 3 σ and 1 π

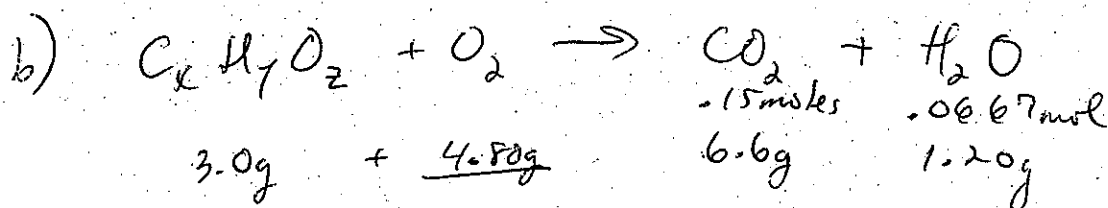
d) $\text{Ca}^{+2}(\text{CO}_3)^{-2}$ Ionic solid

positive / negative lattice units

3. Answer the following concerning aspirin

- The amount of acetylsalicylic acid in a single aspirin tablet is 325 mg, yet the tablet has a mass of 2.00 g. Calculate the mass percent of acetylsalicylic acid.
- The elements contained in acetylsalicylic acid are hydrogen carbon and oxygen. The combustion of 3.000g of the pure compound yields 1.200 g of water and 3.72 L of dry carbon dioxide, measured at 750 mmHg and 25°C. Calculate the mass, in g, of each element in the 3.000 g sample.
- What is the formula for the compound?

a) 16.3%



$$CO_2 = \frac{.9868(3.72)}{.0821(298)} = .15 \text{ moles}$$

$$H_2O = 1.20g \left(\frac{1 \text{ mol}}{18.0g} \right) = .0667 \text{ mol}$$

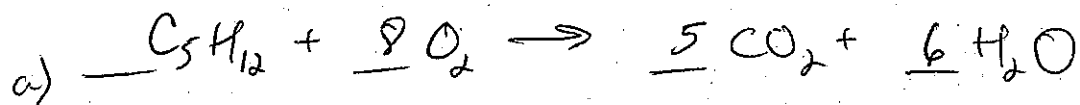
$$C_x = \frac{C}{CO_2} \cdot 6.6g = 1.8g \div 12 = .16 \sim 2.39 \times 5 = 12$$

$$H_y = \frac{H_2}{H_2O} \cdot 1.2g = .133g \div 1 = .133 \sim 2 \quad 10$$

$$O = 3.0 - (1.8 + .133) = 1.07g \div 16 = .067 \sim 1 \quad 5$$

4. Consider the hydrocarbon C_5H_{12}

- Write the balanced equation for the combustion of pentane
- What volume of dry carbon dioxide, measured at 25°C and 785 mm Hg, will result from the complete combustion of 2.50 g of pentane.
- The complete combustion of 5.00 g of pentane releases 243 kJ of heat. What is the value of H for one mole of pentane
- Under identical conditions, a sample of an unknown gas effuses into a vacuum a twice the rate that a sample of pentane gas effuses. What is the molar mass of the unknown sample



$$b) \quad 2.50 \text{ g } C_5H_{12} \left(\frac{1 \text{ mol}}{72.15 \text{ g}} \right) \left(\frac{5 CO_2}{1 C_5H_{12}} \right) = 0.173 \text{ mol } CO_2$$

$$PV = \frac{nRT}{P} = \frac{0.173 (0.0821) 298}{(785/760)} = 4.10 \text{ L}$$

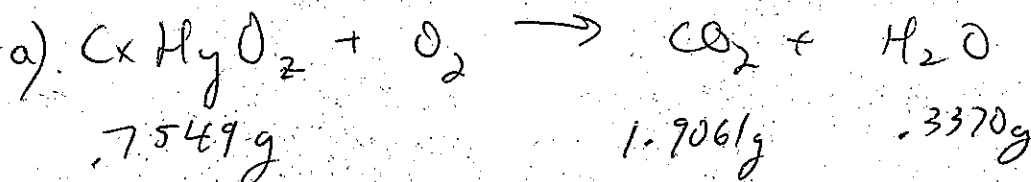
$$c) \quad 5.00 \text{ g} \left(\frac{1 \text{ mol}}{72.15 \text{ g}} \right) = 0.0693 \text{ mol} \quad \text{so..} \quad \frac{243 \text{ kJ}}{0.0693 \text{ mol}} = 3510 \text{ kJ/mol}$$

$$d) \quad \frac{\text{rate } x}{\text{rate pentane}} = \sqrt{\frac{M_{\text{pentane}}}{M_x}}$$

$$2^2 = \frac{72.15}{x} \quad x = \frac{72.15}{4} = 18.04$$

5. Answer the following question about a compound that only contains carbon, hydrogen and oxygen

- A 0.7549 g sample of the compound burns in O_2 to produce 1.9061 g of CO_2 and 0.3370 g of H_2O . Determine the empirical formula.
- A 0.5246 g sample of the compound was dissolved in 10.0012 g of lauric acid and it was determined that the freezing point of the lauric acid was lowered by $1.68^\circ C$. The value of K_f of lauric acid is 3.90. Assume the compound does not dissociate. Calculate the molality of the compound dissolved in lauric acid.
- Calculate the molar mass of the compound in (b) from the information provided.



$$C_x = \left(\frac{C}{CO_2} \right) \times 1.9061 = .5198 \div 12.01 = .04328 = 3.5 = 7$$

$$H_y = \left(\frac{H_2}{H_2O} \right) \times .3370g = .03771 \div 1 = .03771 = 3.06 \sim 6$$

$$O_z = .7549 - \left(\frac{1.9061 + .3370}{.5198 + .03771} \right) = .19734 \div 16 = .0123 = 1 = 2$$

$$b) \quad 1.68 = 3.9(m) \quad m = .431$$

$$.431 = \frac{x \text{ moles}}{.0100012 \text{ kg}} = .00430821 \text{ mol}$$

$$c) \quad \frac{.5246}{.00430821} = MM = 122g/mol$$